Chapter Two

Literature Review

2.1 Introduction

The objective of this review was to critically analyse the existing body of literature relating to quadbike LCE, quadbike use and interventions.

2.1.1 Overview

Agriculture is consistently reported by epidemiologists and Government bodies as a high risk industry both in New Zealand (Steele, 1994; Clarke, 1995; Marshall, Clarke, Langley & Cryer, 1996; Barnett, Houghton & Broad, 1996; Feyer, Williamson, Stout, Driscoll, Usher & Langley, 2001, Horsburgh, Feyer & Langley, 2001; Statistics New Zealand, 2003) and overseas (O'Neill, 2001; ILO, 2004: De Roo & Rautianinen, 2000).

Agriculture and horticulture worldwide account for around half, at least 170,000, of the occupational fatalities per year worldwide, and due to under-reporting in farming it is suspected that mortality rates could actually be 30-100% greater than this. The ILO (2004) also estimate that at least 2% of the world's GDP is lost to injury and mortality in agriculture alone. This amount is ten times the sum of all official development assistance to industrially developing countries. The sheer scale of this suggests that it would have been a priority target for research aimed at injury prevention, but that has not been the case. Just 0.4% of the 97,000 entries in Ergonomics Abstracts for example, relate specifically to the Primary Industries (Moore, Tappin & Parker, 2006a), which provides a very crude comparative indicator of research activity.

In New Zealand the figures are similarly poor for the Primary Industries. Only around 10% of the total workforce is officially in agriculture, horticulture and forestry, but these sectors account for 44% of the workplace deaths (Moore et al., 2006a). A quarter of all fatal injuries occur specifically in agriculture (Horsburgh et al., 2001) at a rate of 21.2 per 100,000 workers. The USA reports 20.3 deaths per 100,000 each year in agriculture (De Roo & Rautianinen, 2000). The high incidence internationally is reported in the literature however as being less skewed towards the poorer countries than might be expected. The New Zealand figure is only 0.8 better

than the 22 per 100,000 reported by Nag & Nag (2004) for farm workers in India - a country with a far less developed occupational Health and Safety infrastructure. Endemic under-reporting has to be assumed, and the methods of estimating can only be tentative, but the fact that the two figures for India and NZ are even remotely close is surely surprising.

Workers in the primary sector have not enjoyed the gains seen in other industries. Productivity per hectare and per worker has risen significantly in New Zealand and elsewhere, but overall human wellbeing on farms worldwide has improved far less. In the USA, the figures for non-fatal cases seen since the 1970s in the other 'hard' industries – mining and construction have improved, but agriculture has resisted the trend (Schenker, 1996). In the UK fatalities in agriculture were noted in 1996 as having remained "remarkably consistent" (O'Neill, 2001).

It has been suggested that this may in part be due to the increased intensity of agriculture, where greater use of fertilisers and pesticides has improved productivity but also therefore workload and risk. To remain competitive, farms have had to do more spraying work through the year and harvest a greater tonnage of crops, with attendant overuse, chemical exposure and fatigue problems (David Caple – IEA Chair for the Technical Committee on Industrially Developing Countries, personal communication). The ILO (2004) estimates there to now be 40,000 deaths a year from contact with pesticides alone.

There has been very little peer-reviewed literature specifically on injury and fatalities in New Zealand Agriculture in the last ten years that is of direct relevance to this research on contemporary quadbike use. The studies that were conducted were predominantly epidemiological with no event-specific investigation, and based on data several years old, from a period when quadbikes were a relatively new phenomenon and three-wheeler ATV still commonly used. The overview study of injury on New Zealand farms by Marshal1 et al (1996) for example, drew on data from the period 1986-1991.

Typical of the conclusions from the epidemiological studies conducted during the 1990s were those by Langley, Clarke, Marshall, Cryer & Alsop (1997), and Langley, Marshall, Clarke, Begg & Reader (1995) on off-road vehicle injuries and fatalities, which again analysed 1986-91 data. Better national surveillance systems and "in-depth studies into specific classes of events" were called for. Priority, they suggested should be given to overturn events, and those involving the elderly, children and drivers whose primary occupation was not farming. Horsburgh et al. (2001) reviewed Coroners' reports from 1985-94 and similarly recommended closer analysis of vehicle operation by older men and rollover events involving embankments and slopes. Unfortunately the necessary studies did not eventuate.

The literature search on quadbike LCE produced few references - 200 scholarly publications internationally, plus 149 popular press items (1995-2001) from New Zealand. The bulk of peer-reviewed material originates from the USA in the late 1980s, the period in which the machines gained notoriety in that country. Subsequent evidence of research activity on quadbike-related injuries and deaths (CPSC, 2005) has emerged predominantly from the organisation that instigated the 1980s actions against the manufacturers - the US Consumer Product Safety Commission (CPSC).

It is rarely possible to identify the four-wheeled quadbikes as a distinct group in these papers, as these early North American studies included both three and four wheeled under the category of ATV. The New Zealand literature of the 1980s and 1990s is similarly compromised as some potentially useful papers include other vehicle types (two, three and four wheeled) under the classification 'farmbike'. Some Canadian and Scandinavian studies include snowmobiles as well as quadbikes in their studies of ATV incidents, further complicating positive identification of vehicle type.

Domestic studies in this area are especially limited. No peer-reviewed scholarly publications that described field investigations of LCE on New Zealand farms were found. The only study (Brown, 1998) that did use farm visits to collect investigative material on occupational LCE was conducted relatively early - in 1992 and although it yielded important data, was not submitted to formal peer-review and was also reportedly weakened by lack of methodological rigour.

It is apparent though from the literature that is available, that the bulk of quadbike LCE in North America occur in recreational settings, and that these riders are relatively young and inexperienced by comparison with New Zealand users of quadbikes on farms. As suggested by ACC (2000), there are indeed gaps in the literature regarding peer-reviewed studies on the context, nature and scale of quadbike LCE in New Zealand farming.

2.1.2 Review methods

2.1.2.1 Process

The process used was a composite method developed from several on-line sources at: Cochrane Library, University of Melbourne, Massey University, University of Queensland and University of Toronto. The following steps were taken to minimise bias and make the process as systematic and repeatable as possible: clarification of study aims, search for all studies reliably relating to these study aims, identification of potential sources of bias, assessment of the quality of the studies, sifting of the studies to select relevant material and interpretation of results.

2.1.2.2 Search strategy

The search was designed in conjunction with the specialist librarian at Massey University Albany. The strategy was also peer-reviewed by Certified New Zealand Ergonomists at the Centre for Human Factors and Ergonomics (COHFE). Keywords were: 'ATV', 'quadbike', 'four-wheeler', 'farmbike', 'farm' and 'injury'.

The search comprised (starting with those that yielded the largest volume of quality references)

1. Web of Science
2. Ergonomics Abstracts
3. On line searches of specific key international advisory sites. Most notably: Canadian Institute for Health Information; Health and Safety Executive, UK, NIOSH, USA: WorkCover [all States/Territories], Australia)
4. www.safetylit.org
5. Personal communication with: researchers, manufacturers and distributors of quadbikes and accessories, industry bodies, farmers with professional backgrounds or interests, insurers and others active the fields internationally
6. ACC library (personal visit)
7. OSH library (personal visit)
8. Google Scholar
9. PubMed (National Library of Medicine USA)
10. Medline
11. Newztext (New Zealand and Pacific media)
12. Index New Zealand(New Zealand domestic magazines)
13. Agricola (US National Agricultural Library)

The sequence and emphasis of the search at each of these sources varied for each of the question areas.

2.1.2.3 Inclusion – exclusion criteria

Table 2.1 sets out the main inclusion and exclusion criteria used, but 'peripheral' studies also had to be included and critically assessed in detail to see if elements of suitable quality could be gleaned to add to the body of knowledge.

Table 2.1 General inclusion and exclusion criteria

	Generally included	Generally excluded
Participants	Working population of any age on farms.	Adventure tourists. Quadbike racers. Children playing. Adult visitors not working on the farm at the time.
Publications	Peer-reviewed journals Conference proceedings Edited books Government agency reports Industry Council reports	Studies funded by quadbike manufacturers or others with commercial interest. Popular media reports unless original source data verifiable.
Recency	New Zealand studies with data more recent than 1985. Overseas studies with data post-1990.	Overseas studies with data pre-1990.
Types of study	Epidemiological studies. Surveys. Engineering evaluations. Follow-up investigations. Case studies.	Studies on three-wheeler ATV. Commercial surveys and promotional material. Any study with no description of methodology.

2.1.2.4 Potential sources of bias

Preliminary discussions with industry members revealed a number of sources of potential systematic bias relevant to the New Zealand quadbike LCE literature. These included political bias introduced by government agencies serving their Ministers, lobby groups such as farming representative bodies and trade unions.

Commercial bias is present reflecting the varied interests of growers, buyers and suppliers within agriculture as well as the manufacturers and distributors of quadbikes and accessories. Acquiescence bias or systematic evasiveness in interviews was potentially present in surveys conducted by authority figures such as OSH Inspectors.

Publication bias is also a factor with the popular and trade press. New Zealand has a quadbike fatality on average every two months or slightly less, and a death is far more likely to be formally investigated for contributing risk factors and subsequently reported in the media and journals than injury events involving quadbikes which occur approximately 50 times a week (based on estimates received from ACC statistics staff in personal correspondence during the study reported in Chapter Three of this thesis). In recognition of this bias the analysis treated all media-reported cases as Serious LCE as defined in Chapter Five.

2.1.2.5 Sifting for relevant material

The literature proved to be scant on all of the questions posed. There was not, therefore, the luxury of being 'inundated with unmanageable amounts of information' as in healthcare fields (Alderson & Green, 2002) that would allow the use of very tight exclusion criteria to yield only wholly relevant, high quality studies.

The published material on the scale and cost of quadbike injuries on New Zealand farms was limited to ACC publications – which drew on its claims database, OSH reports related to fatal incidents investigated by their staff, and academic epidemiological papers published by researchers from Otago University in peer reviewed journals. Systematic analysis by population, context, recency and methodology established that none of the peer reviewed sources addressed the research questions directly. Staff at ACC and OSH responsible for this class of publication assisted in identifying strengths and weaknesses in the data sets and their analysis which aided interpretation. Substantial gaps and inconsistencies were identified, and these findings informed the design of the subsequent epidemiological study – for example, through more reliable and repeatable methods of positively identifying farm quadbike-related injuries from the database.

Approaches were made to the largest provider of private insurance cover for work-related injuries, Farmers Mutual, to gain access to their databases. Initially encouraging, a change of managers resulted in this access being denied after several months of correspondence.

There was found to be no reliable literature on the current context of quadbike use on New Zealand farms. The material discussed in this review draws on small extracts from a handful of studies, mostly quite dated, which provide some indications and inferences of use based on the factual data presented. A systematic review was therefore unachievable, which while regrettable, also underlines the originality and importance of the studies reported in this thesis.

A small number of studies were identified in the New Zealand farm quadbike LCE literature relating to risk factors and interventions, but all had methodological weaknesses and/or significant biases that prohibited systematic evaluative checks (Robson, Shannon, Goldenhar & Hale, 2001; De Roo & Rautianinen, 2000) or meta-analysis of results. To establish relevance and draw conclusions on the actual state of the body of knowledge, the authors or authoring organisations of the key sources were therefore contacted (in New Zealand, Australia, Europe and North America) personally to discuss the relevance of their studies directly, and to establish the state of knowledge internationally.

The studies reported in Chapters Three, Four and Five of this thesis address these identified gaps in the literature.

2.2 Quadbike LCE on New Zealand farms

This section reviews the literature on the scale, costs, context, and risk factors of quadbike LCE on New Zealand farms. There is little published material on the context and nature of these events, but some broad indicators exist on the increasing scale and costs associated.

2.2.1 The scale of the problem in New Zealand

The literature contains more material on the compensated costs associated with injury following an incident than it does on any other aspect of quadbike LCE on New Zealand farms. Accuracy of calculating direct costs is reliant however, on comprehensive and reliable data gathering, capture and analysis, which as discussed later, cannot be assumed. The scale of the problem is also greatly influenced by the indirect costs to the riders affected, most of whom are self employed and working in family owned businesses. These substantial costs remain uncalculated. In broad terms however, it appears clear that the scale of the burden related to quadbike LCE on farms is serious enough to warrant immediate action, and is growing.

In 2000, the Occupational Safety & Health unit (OSH) of the Department of Labour identified quadbikes as the most common single factor in traumatic deaths on New Zealand farms (Wilson 2000). In the four years from 1999-2003, there were 23 quadbike-related deaths, in comparison to 22 tractor-related fatalities, and only three on-farm fatalities related to large animals (OSH, 2006). No exposure data is available however which would enable comparative incidences to be estimated.

Similarly, comparisons with road vehicles provide findings which are tentative at best due to a lack of exposure data. As shown in Table 2.2, using estimates from this research on total rider numbers, one in 29 quad riders will file an ACC claim for injuries each year as opposed to one in 43 car drivers. Quadbike riders therefore appear to have a higher risk of injury, but less chance of death as only one in 10,000 riders will die from quad-related incidents as opposed to one in four thousand car drivers.

Table 2.2 Comparison of the relative likelihood of death or injury from average quadbike usage and average car use

	Quadbikes	Cars
Number in use	70,000	1,900,000[1]
Fatalities per year	7[5]	477[2]
ACC injury claims	2,400[4]	43,813[3]
Ratio: fatalities to vehicles	1: 10,000	1: 3,983
Ratio: ACC injury claims to vehicles	1: 29	1: 43

[1] As at September 2001 (Slappendel, 2002)
[2] For the year 1999-2000
[3] For the year 1998-99
[4] Estimate based on the findings from this study.
[5] Mean average for the three years to July 2002.

Comparative data is otherwise unavailable on deaths and injuries on farms by various vehicles that would answer the common question - which are actually the most likely to be involved in injury events? The discontinuation of narrative data in New Zealand Health Statistics public hospital discharge injury data files (Langley, 1998) would alone make this task difficult, but more fundamental surveillance system weaknesses also reportedly exist (Wagstaffe, 2005). The fullness and reliability of centrally collected data generally in New Zealand has been criticised by Laird (1995) and more recently by Wagstaffe of the National Occupational Health and Safety Advisory Council. He suggests that 'up to 80% of work-related deaths are neither documented nor investigated'. These include disease cases where the work-relatedness may be in dispute though. All 'unnatural deaths' in New Zealand are required to be referred to a Coroner for a report and so all quad-related cases could be expected to come under this. However Horsburgh et al. (2001) found only 52% of Coroners' reports for deaths in agriculture also contained OSH investigation findings. Coroners' reports do however provide data from a variety of sources and hence enough contextual clarity to identify quadbikes.

Injury data are not available from ACC for the first decade of quadbike use as no narrative entries were made in the database, and so quadbikes cannot be identified using a keyword search. The coding categories are too gross to isolate such cases in any other way. Fatalities provide some indication of the increasing scale of the problem.

In the 12 year period to 1989 a total of 12 fatalities was recorded in the hospitalisation data but these were for all two, three and four wheeled motorcycle incidents on farms combined (Langley et al., 1995). Drawing on data from 1978 to 1987 the researchers were able to positively identify only 29 quadbikes and 81 three-wheelers, but 660 'farmbikes'. They rightly concluded there to be 'an urgent need to accurately determine the contribution of ATVs to motorcycle crashes on farms'. Langley Marshall, Begg and Reeder (1995a) in their study of non-traffic motorcycle crashes 1980–1989 (not just on farms) just 0.8% were positively identified as quadbikes. In 77% of cases the machine type was unspecified or just given as 'farmbike'. A weakness of an epidemiological approach in isolation demonstrated by these two examples is that an otherwise rich data source can flounder through lack of basic contextual data. Accurate identification of the machine type is clearly critical for drawing conclusions that may assist intervention design where conceptual operating differences exist, as with two, three and four wheeled bikes. In the 1980s when the data used by Langley et al. was being collected, the significance of this was presumably not recognised.

According to Horsburgh et al. (2001) there were four quadbike fatalities (plus two from three-wheelers) positively identified from Coroners reports between 1985 and 1994 – roughly one a year. The incidence increased beyond this date with 28 people dying while using quadbikes on New Zealand farms during the 1990s and the annual incidence trending up. Since 1997 the pattern has been consistent, with on average six to seven fatalities annually in New Zealand related to agricultural quadbike use (OSH, 2006).

2.2.1.1 Contradictions in perceptions and acceptance of risk

Although clearly a source of major losses, the perceived hazardousness of these new devices relative to other risks on farms may have been overstated at times in comparison to more long-standing risks possibly seen as less avoidable. In their overview of injury on New Zealand farms, Marshal1et al. (1996), noted that between 1986-1991 tractors and horses were still the major sources of deaths, hospitalisations

and compensated injury. Even sheep-related injury costs for ACC at this time were 20% greater than those for quadbike incidents. As Table 2.3 shows, more people on New Zealand farms in this period were killed or injured by horses than quadbikes, but these cases received less press and researcher attention – perhaps due to a long-standing fatalistic acceptance of animals as injury agents on farms.

Table 2.3 Incident outcomes by injury vehicle 1986-1991 (derived from data in Marshal1 et al., 1996)

	Deaths %	Hospitalisations %	Injury %
Horses	8.4	**20.7**	**8.3**
Tractors	**18.2**	6.5	3.0
Quadbikes	5.8	15.7	6.4
Other	*67.6*	*57.1*	**82.3**
Total	*100*	*100*	*100*

There has been strong support in New Zealand for the imposition of age restrictions for quadbike use. Yet the suggestion that an age restriction should also be contemplated for horse riding – based on the injury data – was considered laughable. The consensus view was that horses represent a risk that should be wholly managed by parents or caregivers; the rationale being that if legislation excluded children until they were 16, they would quite possibly be getting their first taste of a potentially dangerous animal with far less adult control than they would if they started at a younger age. Those on the AHSC against having any enforced age restriction argued that you should introduce your children to any farm machinery as you would to horses – under close supervision, with safety paramount, with well maintained gear, in a tightly controlled environment and at whatever age they demonstrate the maturity and physical capability to handle it. They conceded however that a powerful automatic quadbike with the keys left in was easier to catch and mount than a 17 hand hunter loose in a paddock.

A similarly interesting pattern of selective fatalism has emerged in adventure tourism in New Zealand (Bentley, Page & Laird, 2001; Bentley, Page & Walker, 2004) where calls for tighter controls on quadbike use are more common than for other activities. Horse riding has more than twice as many injury incidents per million hours of participation (759) than mountain biking (304), and quadbikes and skiing

are roughly equal third behind these. However, these other incident types warrant little media attention in comparison to the quadbike cases.

2.2.2 Costs

In recent years the costs of new claims for injuries has risen markedly, and the costs of ongoing claims even more so, as shown in Table 2.4

Table 2.4 Total ATV-related entitlement claims by year. Source: ACC industry presentation 2004.

	New		Ongoing*	
	Number of injury claims	Cost of claims (NZ$ millions)	Number of injury claims	Cost of claims (NZ$ millions)
2000/01**	713	.7	6	.09
2001102	828	1.10	117	.47
2002103	930	1.71	173	1.13
200314	1166	1.79	189	1.84
Total	3637	5.37	479	3.54

* Ongoing claimants are those who continue to receive payment after also being paid in a previous year.

** Figures for the 2000-2001 year were affected by a government regulatory change (since reversed) that allowed employers to seek insurance from private firms as well as ACC.

The average cost per claim of both new and ongoing claims has increased in recent years as shown in Figure 2.1, reflecting not only higher medical and pay-related costs but also, ACC suggest, an increase in average severity. Interestingly, this is counter to the trend in the USA where recent a study (Axelband, Stromski, McQuay & Heller, 2006) has found no such increase in severity of injury from quadbike incidents. New claims averaged $1,090 in 2000/01, $1,840 in 2002/03 and $1,530 for 2003104. Ongoing claims over the same time more than doubled in three years; from $4,050 in 2001102, to $6,520 in 2002103 and up to $9,760 in 200314.

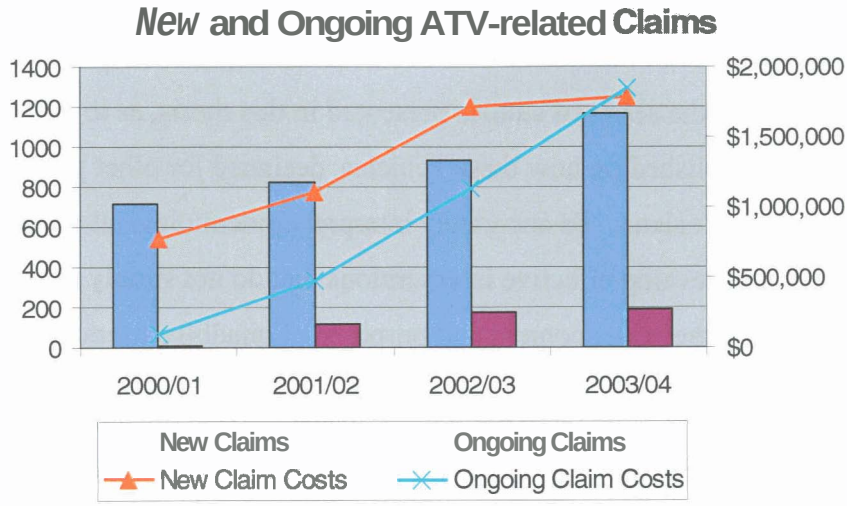

Figure 2.1 Total numbers and costs in NZ$ of new and ongoing ACC claims

Further study is needed to investigate whether the actual severity of injuries is increasing, for example due to heavier machines resulting in more serious acute damage and/or more entrapment under the vehicle. The increasing burden of ongoing claims in New Zealand may be reflecting the older rider population that we have here in comparison to North America. Older riders may have: reduced ability to extricate themselves after rollovers, higher average income replacement costs, higher susceptibility to acute musculoskeletal injury and slower recovery times.

2.2.3 Context

An understanding of the context of use on farms experiencing LCE is a critical component in the series of studies presented in this thesis, as to date little has been formally established on how these vehicles, designed for other purposes, are actually used in New Zealand. To accurately interpret epidemiological and investigative findings and develop effective interventions that do not simply replace one problem with another, the wider context and purposes of quadbike users must be clear.

In 2001 it was estimated that there were around 70,000 quadbikes in use in New Zealand, and a further 7,000 new machines sold each year (New Zealand Motorcycle Distributors Association [NZMDA], 2001). The country has roughly 80,000 farms in total, indicating a high level of uptake. However, neither the number of farms using quadbikes nor the total number of individual riders was estimated in the literature reviewed. As a result, exposure hours per rider could not be estimated.

Quadbikes have to a large degree replaced light tractors on many farms, as these cheaper, lighter machines become more powerful and equipped for a wider range of tasks (Brown, 1998). Trade estimates suggest 5000-6000 machines are now sold annually in New Zealand, with a life expectancy of approximately seven years, based on trade-in data collected by the NZMDA from dealerships around the country. The new quadbike market is worth between $75 million and $95 million a year (NZMDA, 2001).

The study by Brown (1998) in 1992 was the only New Zealand study found in the search that provided contextual data linked to specific LCE. It provides a valuable description of some of the characteristics of three and four-wheel ATV use in Southland at that time. The study would have been further strengthened by collection and analysis methods that linked the richness of the available contextual data into the incident investigations.

95% (225) of the 236 farms surveyed used ATV, at an average of 1.5 machines per farm. All came with towbar fitted as standard and Brown reports that "there is almost universal expectation that ATVs will be used to tow at least a trailer ... [and]

... silage wagons, fertiliser spreaders and other loads up to 1000kg are occasionally towed". One tonne would have been roughly three or four times the weight of the quadbike at that time as machines over 350-400cc were not being produced. He concludes that in Southland the predominant use of ATV at this time was as a light tractor.

2.2.3.1 The joint Federated Farmers / OSH study

Four years later, the joint Federated Farmers / OSH (1998) survey of 377 New Zealand farms (discussed in detail below) collected data from the owners or managers of farms where quadbikes were used, but no description of the methodologies used was provided in the final report which makes it impossible to confidently gauge the strengths and weaknesses of the research.

Anecdotal evidence however suggests certain biases. When interviewed in 2002, one of the team (Ward, 2002) noted that the sampling had been heavily skewed; 377 usable returns were collected from 600 forms sent out, but the postings, he advised, were mostly to individuals personally known to the survey organisers as "people who would have something to say". If true, then the sample invited to take part would have not been representative of the membership as a whole.

It is also important to note that the organisation does not represent the whole farming sector. Approximately 17,000 of the 80,000 New Zealand farms are currently members of Federated Farmers, and traditionally it is the larger farms that choose to join - according to personal communications with both Federated Farmers officers and journalists in the trade press. Smaller lifestyle block holders, part-time farmers and small specialised niche operations are apparently under-represented.
The motivations for the establishment of the body were political (http://www.fedfarm.org.nz/history.htrnl), seeking in part to balance the growing influence of the trade union movement by a stronger rural lobby. A strong political lobbying role remains, which was taken into account when reviewing their study.

Ward also noted that inconsistencies between regional offices in survey administration resulted in difficulties in merging data nationwide, "some inspectors decided they had better ideas about what questions to ask, and so asked different ones".

The lack of rigour is frustrating, as it is likely that some of the findings from this study are probably accurate and usefully generalisable. But the apparent shortcomings in methodology seriously limit it's usefulness. For example, on the question of quadbike daily usage (average of 11 hours per rider), the findings tally precisely with the figure reported in Chapter 4 of this thesis. By contrast, only 39% of respondents knew of an incident involving quadbikes, which compares to the earlier findings of Brown (1998) in Southland where riders admitted to having had on average two each. The responses were also collected by OSH inspectors who stood at the farm door with their survey forms; a method of administration that could be expected to lead to conservative reporting from small businesses.

Political bias was to be expected in the Federated Farmers & OSH (1998) study as it was not in the interests of the farm-owning community to present a picture that might encourage further regulatory controls on their operations. The 1998 study therefore provides a useful position statement by the main farming lobby group of 1995-6 on how farm usage of quadbikes could be viewed, and what it would like to see done nationally to control future losses. Indicators of such bias can be seen in the semantics. For example, 92.5% stated that they carried passengers. The choice of the word 'stated' - in favour of 'admitted' - is interesting. The latter infers some wrong-doing, the former asserts that the carrying of passengers, animals and large loads is a fact of life to be taken into account in further discussions on risk management.

The findings that are presented on the induction training of employees also provide clues on respondent profiling. The question 'what information (on quadbike use) have you provided your employees' makes it clear that the study is actually aimed at

the farm owners and managers, not all quadbike riders as a population. Employee corroboration of the responses is not sought. The users voice is not sought explicitly. Findings on context of use that are most likely to be robust and useful relate to the factual questions where there would be no cause for politically cautious answers. For example: quadbike make, age, engine size and engineering improvements desired. Of note is that the heaviest machines in use in the 1995-6 study were 450cc. In 2006, the largest machines were up to 700cc, potentially reducing ease of handling by the physically weaker riders and increasing the proportion of riders who would not be able to push the machine off if trapped under it after a rollover.

No data were directly collected by the Federated Farmers and OSH survey on the tasks that the quadbikes were being used for, or their suitability for those applications. Suggestions were recorded though regarding potential interventions to improve performance and safety, which give some indirect indication of tasks being undertaken and the inherent system weaknesses. For example, the use of baffles in spray liquid tanks to reduce de-stabilising surge when cornering or tipping is commonly requested.

2.2.3.2 The media

The search of the popular media generated indications on the importance of quadbikes on modern farming systems and their impact on rural employment. In an Otago Daily News (16th May, 2002) piece entitled *ATVs* Revolutionised Our On-farm Transport, the Manager of an 8500 acre coastal South Island sheep and cattle station comments that "thirty years ago (the farm) had four to five shepherds and a quarter of the stock it has now. Now we have one man doing that work with three or four extra arriving for a big job".

The impact of this extends beyond the farm. He notes that "less people live in the country now because of the way they [quadbikes] have enabled farm owners to double production with only half the staff. We'd be lost without them. We'd have to reassess our whole operation."

2.2.3.3 Industry data

There is a representative body for the importers, distributors and dealers of quadbikes in New Zealand – the Motorcycle Distributors Association, which includes all the major brands, Honda, Suzuki, Kawasaki, Yamaha, and Bombardier. The Chair, Cooper-Smith **(2004)** reported that "Honda sells more ATV to farmers per capita in New Zealand than in any other country in the world," and that this pattern is true for the other brands to a greater or lesser degree. He stated that their sales to occupational users were 92% in New Zealand and 70% in Australia. According to Bill Grise, Head of Suzuki New Zealand, there was a significant occupational market in UK (84%) and somewhat less in numbers than Australia, but exact figures were not available. However, "farm use of quads, as we know it, is unique to New Zealand".

Reliability of this information cannot be easily checked, and no independent studies conducted using industry data sources were found. However, during the data collection for the context study reported in Chapter three, no possible motivations for the NZMDA to be deliberately misrepresenting the situation were suggested. The only reason for buyers when returning their warranty cards to the dealers to be falsely stating predominantly occupational use - when they actually bought it for recreation - would appear to be tax advantages. Claiming personal toys as business expenses is not unique to New Zealand though, and so is unlikely to be responsible for the marked difference.

2.2.4 LCE risk factors and their interactions

Quadbikes have prompted concern within rural communities since their release in the 1980s but very few studies on their safety have been conducted in New Zealand. Most of the data that is available is now too dated, of questionable quality, too regional or too politically skewed towards the views of employers to be usefully generalised to the occupational farm rider population as a whole. There has not been a sustained research contribution to support intervention work. The most recent effort, by an individual OSH staff engineer – to compile a centralised quadbike LCE investigation database - failed through a lack of commitment and support at both local and national level.

The earliest published study in New Zealand was by OSH (Brown, 1998) which reported on a study in Southland in 1992 conducted as a follow-up to an unpublished Massey University student assignment by the author in 1990. The work came at a time of high public awareness of ATV incidents in Southland as evidenced through letters to the media and medical press by local figures including Dr Peter Snow, an Invercargill family GP (Snow, 1987).

2.2.4.1 The Southland OSH study

Some 236 survey forms were administered by six inspectors on farms in separate allocated sections of Southland. They reported 100% cooperation with their survey. The sampling was reported to be randomised, but subsequent comments via personal communication with OSH staff (Ward, 2002), who was involved with the work, contradict this. His view was that the inspectors visited those farms where a friendly reception was likely. Arguably, each interviewer/inspector visiting 40 of their friends and neighbours (if that is what happened) is a repeatable methodology, but it is a weak one for the purposes of measuring characteristics relating to the rider population as a whole in a region.

A surprising number of LCE were reported. In all, 58% of the respondents (n=131) reported having had on average two hazardous incidents while operating an ATV (three or four wheeler) - that they could recall in enough detail to include in the

study. Many operators stated that the number they had experienced where they had escaped serious injury were too numerous to count. Of the 197 incidents where full details could be recalled by the subjects, 42% resulted in personal injury, and half of these were serious enough to be classed as Requiring Notification to OSH. In two cases the operator was too badly hurt to return to farming, and in one case was off-work for over a year.

Brown notes quadbike users were loath to take the time to recount incidents that had not resulted in injury as they saw little potential benefit. The actual incidence of loss of control events at this time in Southland was therefore higher than indicated by these study findings. The author suggests that without any means of cross-checking medical or ACC records, the severity was probably similarly understated, due to stoicism in the farming community.

Event types most commonly leading to injury were reported by Brown to be rollovers, often preceded by jack-knifing of the trailer being towed, and the subjects were asked to assess behavioural, design and environmental factors in the events. The subjects experienced some difficulty in this, apparently, and as a result the researchers prepared lists of single word descriptors of typical factors from which subjects would choose the most relevant to describe the event. It unclear whether or not subjects could offer descriptors not included on the lists.

The results are therefore descriptions built on combinations of single factors. For example one event was described as: 'slope', 'configuration', 'procedure used', 'urgency'. While valuable in a field where previously there was no data at all, the method failed to capture much of the full contextual richness that was available given the face-to-face nature of the study. Importantly therefore, interactions between risk factors were not considered, and organisational factors such as the reasons for the urgency were left unexplored.

Further limitations of the Brown (1998) study, that may or may not exist, are inter-researcher reliability problems; no description of the training for the interviewing methods is offered in the report.

The discussion by Brown included a number of clear areas for intervention efforts, including post-event system weaknesses. There was a delay of six years between the study and publication however which may partially explain why the recommendations made in this study appear to have been largely ignored. Southland is also not representative of the country as a whole with regard to climate, farming mix or quadbike modification habits. It sits at the southernmost tip of the South Island, exposed to cold conditions coming up from the Antarctic, which influences the design and usage patterns of agricultural vehicles substantially. The findings might therefore have been seen as too region-specific.

2.2.4.2 Federated Farmers and OSH survey 1998

Also published in 1998 was a report containing the results of a joint survey by OSH and Federated Farmers of New Zealand of 377 farms nationwide. This was conducted to "gather the opinions of farmers on the safe use of All Terrain Vehicles".

No details of the methodologies for either collection or analysis were provided in the report which was subject to criticism internally within OSH (see 2.4) on various grounds including political bias in the sampling – as discussed earlier (2.2.3.1). 147 respondents were "aware of accidents and gave details of the events", but the integrated nature of incidents and risk factors are not explored. The presentation style is more akin to a press release, with little opportunity for the reader to assess the original data.

The main value of the report therefore is not as an analysis of quadbike LCE risk factors but instead as a record of how the owners of the larger farms in New Zealand in 1995-96 wanted the risks to be perceived and, indirectly, the risk management plans constructed. For example, the greatest risks when operating an ATV were seen

to be the operator's lack of knowledge, skill, awareness, and training – plus poor attitude. The report stated that the three most common interventions identified by the respondents to reduce accidents were: reducing speed and riding to the conditions, individuals developing knowledge and experience through training and skills courses, and the fitting of [tertiary] devices – roll bars or safety frames. Of note is that the first two place the onus on the riders to modify behaviour, and the third does not in fact reduce incidence of LCE at all, but instead limits the costs incurred when they do occur.

2.2.4.3 Child passengers

A high proportion of published research on quadbike injuries and fatalities in the last decade relates to children as independent riders (Goldcamp, Myers, Hendricks, Layne & Helmkamp, 2006; Shults, Wiles, Vajani & Helmkamp, 2005), and the mechanisms by which they become injured (Graham, Dick, Parnell & Aitken, 2006). No research at all, however, has been published specifically on the potential role of child passengers as contributory factors in occupational quadbike LCE on farms. The machine is designed for active riding, and the long seat is provided to allow the user to weight shift in ascent and descent – not to allow space for a pillion (Cooper-Smith, 2004). There are however indications of the extent to which carrying young children when going about daily tasks is normalised as a practice in New Zealand.

In a northern region of New Zealand in 2002, a charity (Plunket, 2002) that leased child car seats to the community was approached by farmers requesting old seats that they could bolt onto their quadbikes to keep the toddlers and infants safer. The practice of attaching these seats had reportedly been recommended by the local FarmSafe trainer, presumably in recognition of the fact that carrying such young children was widely accepted, and that this measure would at least reduce risk.

Encouragingly, some interest in the social context of quadbike LCE is now being shown in New Zealand. Basham, Nicholls and Campbell (2006), in their study specifically on child deaths and injuries involving quadbikes on New Zealand farms, concluded that the difficulties of obtaining adequate child care in rural areas is a

primary factor in the high toll of injuries to the young. Changes in rural communities have resulted in more households where both parents work, and Basham et al., suggest that during the school holidays especially, children are taken out on the bikes with the adults during working hours for lack of an alternative. There is no discussion though regarding how the presence of the child may have influenced the events leading to the LCE, or its outcome.

2.2.4.4 Department of Labour (OSH) Accident Investigation Reports

OSH in New Zealand investigates all fatalities, and, in theory, all serious harm cases reported to them. However, the system appears better designed to meet the immediate needs of local coroners and OSH inspectors in their dealings with individual employers, than to build a nationwide understanding of quadbike LCE on farms.

For example, the investigations into quadbike LCE are not compiled by OSH at any central point for analysis, instead remaining in files in the local offices. Only brief narrative entries that identify the fatalities by mechanism are logged nationally. In addition, the investigation methods used by the inspectors in the various parts of the country are not standardised, and attempts to introduce more rigour across the regions in the 1990s were unsuccessful according to the OSH spokesperson for agriculture in 2002 (Ward, 2002).

In 2000 an Auckland OSH inspector, Weng Low, developed a study to conduct engineering tests on rollover protective structures (ROPS) to follow up those conducted by University of Auckland in 1998 (Barbour, 1998). As part of the study preparation, Low attempted to describe the nature of serious quadbike incidents by sending out to inspectors an improved style of investigation sheet 'Essential Data for ATV Accident Investigation Report'. His two-page survey form comprised: basic details of the rider and mechanics of the event, the balance being questions on the machinery (most notably the rollover protective structures [ROPS]) and the physical condition of the equipment after the event.

The free narrative section for Summary of Event provided space for only **10-20** handwritten words and as a result little contextual data could be gained. There was also a lack of cooperation from inspectors around the regions generally. Over the **20** month period from **Aug 1999** to April **2001,** only **19** of the new investigation forms were returned. Two of these were fatality cases (one was a double – father and young son), during the last **12** months of this period other OSH records show seven fatalities around the country, and so not even major investigations documents were being sent on to the research coordinator (Low). Efforts to coordinate national data compilation on **quadbike** LCE ceased at that point. The study did not continue and no analysis of the set of reports that had been filed was conducted by Low.

The **18** LCE scenarios in the reports made available by Low were analysed as a set. Of the **18:**

- **17** took place in dry weather
- Surface conditions were predominantly hard, but in some cases slick from clover grass or rain
- **All** but one involved a **rollover** of some description with the machine coming off its wheelbase and throwing the rider
- **25%** of subjects were female
- Four riders were over the age of **40** and four under **20** (one unknown)

Analysis by scenario characteristics is shown in Table **2.5.** Of interest here is that the most common event type involves the rider straying off line or striking a visible obstruction, at speed; but the investigation reports do not include any comment on why the rider may have committed the error.

Table **2.5** Analysis of OSH investigation cases by scenario

Scenario	**n**
Lost control after touching lump or edge at speed on a track	7
Flipped while ascending a track or paddock slope	3
Rolled while traversing hillside with spraying tank on	2
Lost control in descent	2
Reversed over steep bank	1
Jumped creek (nearly)	1
Standing up shooting from the seat while moving	1
Crushed against handlebars when reversing under a fence top rail	1

A major weakness in at least two of these reports is the exclusive reliance on data from third parties. It is clear from the language in these cases that the event accounts have been provided to the OSH Inspector entirely by someone who (presumably) witnessed the incident instead of, rather than in addition to, explanations from the rider themselves.

2.2.4.5 Media reports

The aim of this analysis was to assess the nature of quadbike LCE as reported in the New Zealand popular media.

The method used for this was a keyword/subject search of ALL FIELDS (quadbikes, ATV, All-Terrain Vehicles, farmbikes) of domestic media sources via Newztext (newspapers) and Index New Zealand (small magazines) for the periods 1995-2001, with a subsequent update 2001-2006. The 1995-2001search by COHFE staff prior to the fieldwork reported in this thesis yielded 149 hits. The 2001-2006 search revealed 2894. Of note is that when the expansion in the number of items contained in the search systems is taken into account we can see an apparent increase in the media interest with a higher proportion of stories including material on quadbikes, as shown in Figure 2.1; an indicator of the continued growth in importance of these machines in the rural New Zealand economy.

In the 1996-2001 cuttings, only eleven articles related to incidents were found, with 17 separate LCE identified. All but three involved rollovers.

The search for 2001-06 was refined by adding keywords (injury, injuries, death, fatality, rollover, damage) to cull a large volume of items unrelated to specific incidents.

Typical of these are the running public exchanges between farmers and OSH on the need for regulation. An Otago farmer arguing against controls received this reply from Brett Murray of OSH in the Daily News (p8, 28 May, Edition 1, 2005) "His comment that victims of ATV fatalities kill themselves through 'acts of monumental

stupidity' is naive at best, despicable at worst and highlights the difference between opinion and informed, considered opinion."

More recently the tragic death of eight year old Molly Vanner on a Taranaki farm while under the supervision of her father has generated much media debate, and revealed the extent to which the farming community allows children to operate plant (machinery) designed for adults. The Children's Commissioner concluded that "the fact that a dozen people testified in his (the fathers) defence that they (also) allowed their young children to drive ATV unaided did not make it right" (Kiro. Radio New Zealand Newswire 10/3/2006: 15:34).

The refined 2001-06 search yielded 261 items which provided details of 13 specific incidents (10 fatal). Of note perhaps is that of the 35 quadbike-related deaths in that period, 25 therefore were effectively unreported in the popular press.

The most detailed accounts were for the high profile fatalities. In the Molly Vanner case, it was reported that divided attention on the part of the supervisor and acceptance of the child using the machine proved fatal. The following is taken from the New Zealand Herald.

Vanner said he had stepped off the bike to make a cellphone call to a concrete company and was thinking about 10 things at the time Molly asked him if she could round up the cows. The bike was in gear and the little girl, who had been learning to ride a 50cc bike, 'putted' off across the paddock. He saw the weight of the bike pushing the accelerator and started running to help his daughter who he knew was in trouble. "And then it rolled and I thought, please let it be fortunate enough that it actually rolled over the top of her and, you know, missed her, and then when I got to her she was just lying still."

"I checked for a pulse. I thought I had a pulse, I honestly did and she vomited and I thought, this is what I've been trained to do." Then he lifted back her eyelids. "I've blipped enough bobby calves and dead calves. I've seen their eyes and I just thought, this is not right."

His daughter just wanted to help him, he said.

"I was thinking about the concrete truck and every other [thing]. We had about 10 jobs going on at once and I know that's a pathetic excuse and I was thinking all these other things, but my bloody safety went out the back door you know and I'll admit to that." (New Zealand Herald March 8th, 2006)

Summary descriptions of the 13 separate incidents which were reported with sufficient detail are shown in Table 2.6. As can be seen, very few preventative measures are suggested in the articles; a missed opportunity to reinforce key messages such as those set out in the Agricultural Health and Safety Council *Guidelines for the Safe Use of ATVs on New Zealand Farms* (AHSC, 2002).

Table 2.6 Incidents reported in the New Zealand media 2001-2006

Incident Date	Incident description	Interventions suggested
Jan 2002	14 year old Taranaki boy killed while helping with milking on father's farm. Went to move an electric fence on another part of the farm and didn't come back. Was found pinned 20 minutes later. It appeared his wheels had got caught in a rut on a bank.	None.
March 2002	38 year old man suffered serious head injuries when his machine rolled down a bank. Flown to Wellington hospital where he died.	None.
May 2002	16 year old male killed when gathering firewood. His quad is believed to have hit a tree branch or obscured object, flipped and came to rest on his neck.	Resuscitation within seconds rather than minutes was needed.
Oct 2000	39 year old Man killed when his quadbike hit the front of a train on a private crossing. Coroner concluded: having hood up may have reduced hearing, overgrown crossing reduced visibility, occupational stress and tiredness also present. It was the second vehicle/train fatality on that farm that year.	Lockable gates, better visibility and more holistic approach to safety on private level crossings.
March 2003	16 year old male was working alone pulling down old fences using his quadbike. Wire he had looped around the handlebars severed his thumb off. He collected it and ran two Klm with it to get help. Leeches flown in from Australia to keep the blood flowing to stump while thumb re-attached.	None.
May 2002	16 year old working on farmland in the Manawatu province found trapped beneath machine. Dead before emergency services arrived.	None.
August 2002	14 year old girl on friend's farm in the Waikato, crossing a sloping paddock with young friend. Stopped at the gate and machine started to roll back. She panicked and hit throttle instead of brake. Machine flipped over on her, crushing her chest. She died.	Don't ride quads at this age.
August 2002	22 year old woman chasing cows that were trying to get back to their calves when one turned in front of her. Can't remember what happened but suspects she swerved and hit brakes, getting thrown off. Head injury.	Can't think of what else she could have done.
Nov 2002	67 year old man spraying weeds on his Rotorua property rolled his machine. He righted it, applied first aid to a serious leg wound and headed for home but crashed a second time. He tried to right it again but died at the scene, possibly from loss of blood. The man was found by his wife.	None.
August 2003	Woman died after incident on a public road near Invercargill.	None.
Oct 2003	31 year old man died from head injuries after incident on a public road near Invercargill.	None.
Oct 2004	12 year old Waitara boy found dead under upturned quadbike after failing to return from feeding calves. No indications of what happened.	None.
April 2005	68 year old man helping on mate's farm near Nelson, hit a sheep while moving a mob down a road and tipped over. Found crouching against machine by friend but rode the bike home. Internal injuries diagnosed and helicoptered to hospital. Operated on but died later.	More prompt medical attention.

2.3 The context and nature of quadbike LCE overseas

There is a widely held industry belief, with some support (NZMDA, 2001), that quadbikes are used predominantly for work in New Zealand, and mostly for play in other countries. There are indications that although the North American market is probably still dominated by recreational users, there may be increasing occupational use of quadbikes for farming and ranching. If so, this could assist if influencing future designs towards those more suited for stockwork purposes. There is also some evidence of pockets of use that may bear more resemblance to the way that they are used in New Zealand. There appear to be some parallels with mixed farming in hill country areas of Britain and Ireland, and also some parts of Australia. The very high uptake of machines in isolated communities reported in Alaska suggests that there may be opportunities for sharing of data on community-wide intervention programmes with countries such as New Zealand where quadbikes have a similarly prominent role in rural life.

In exploratory meetings with industry members it was suggested that there was a significant difference in the way quadbikes are used in New Zealand in comparison to North America. These assumptions were consistently supported by interviews with the importers' association (Grise, 2002), and individual companies at national and regional level. As part of this literature review, a limited survey of the types of quadbikes being offered by dealers in New Zealand and the USA was conducted (in 2002- updated in 2006), via the marketing material content to provide an unobtrusive measure of respective target markets.

The websites of the national distributors for each of the four major suppliers (Honda, Suzuki, Kawasaki, and Yamaha) were used in the survey to avoid bias from individual dealerships in rural and urban areas. In all cases the manufacturers categorised the quadbikes as either Sport or Utility models. Side-by-side models such as the Kawasaki Mule and child-size models were omitted from the survey.

Findings are shown in Table 2.7. It was found that the New Zealand sites offered more utility than sports models and that in all cases the utility models were presented in both text and photographic settings as farm vehicles. In all, 40 models were offered to New Zealand buyers.

The same manufacturers' central websites in the USA showed more models overall (77) and interestingly a greater number of utility models (49) than sports quadbikes (28) – a similar proportion to that of the New Zealand market. The further analysis of material content revealed that the approximately two-thirds of the utility models on the USA sites were actually being marketed at trail riders and hunters – not farmers and ranchers.

Table 2.7 Comparisons of quadbike model types listed in marketing material

	Listed formally as Sports Models	Marketed for sports, trail riding or hunting	Listed formally as Utility Models	Marketing material shows or mentions work applications	Total
USA	36% (28)		64% (49)		100
New Zealand	30% (12)		70% (28)		100
USA		83% (64)		17% (13)	100
New Zealand		30% (12)		70% (28)	100

Interestingly the Yamaha site used a farming scene as the link to the Utility page but all 15 of the models were shown in hunting or trail riding contexts for the promotional pictures; Figure 2.2 is a typical example showing gun stowage and night camouflage.

Figure 2.2 USA - hunting (Utility) model

That collisions with automobiles on public roads remains the most common cause of quadbike fatalities in the USA (Ayers & Oldham, 2001) further indicates the low relative level of occupational off-road use in that country.

However, the published literature reveals little hard data on actual occupational usage in the USA – especially by adults. A recent major study of nonfatal ATV-related injuries on farms (Goldcamp et al., 2006) - that would have been very useful for comparative purposes, included just young riders, as is the case for much of the recent North American literature. In the sole study focussing directly on context of use by all ages, Rodgers (1999) conducted a telephone survey of 500 riders in all parts of the USA (except Alaska, Hawaii and the scattered 6% with no telephone service) for the US Consumer Product Safety Commission. Rodgers found that half reported using their machines at least some of the time for farming and ranching tasks specifically as well. In total, 73.7% stated that they used their machines for some occupational purposes, an increase from 52% recorded during their 1989 survey. Other sources also indicate greater uptake of the machines for non-recreational purposes. The outreach section of Colorado State University for example offers ATV Safety education resources aimed specifically at farmers/ranchers (Ayers & Oldham, 2001). The total amount of occupational hours worked on quadbikes was still quite limited though in the Rodgers study. Half of those doing occupational work with the machine used it for less than 30% of their riding time.

Those riders with the most non recreational usage were older (mean age 36, S.E 3.5, versus mean age 29.5, S.E. 1.4), were more experienced and did less total hours on their machine.

It is clear though that the population of riders in both the USA and Canada is still generally young in comparison to New Zealand. In the USA 40-50% of quadbike injuries and 35% of deaths involve children. Rodgers (1999) found 67% of users in his telephone survey of 500 US riders to be in the 16-24 age group, and four fifths to be under 45 years of age.

Legare (2002) in his study of Canadian off-road injury events reports three quarters of the quadbike and snowmobile using population (in personal communication he advises that they use the same trails through the year with one or other machine depending on snow conditions) to be aged between 20-39. The under-15 age group comprise 25% of quadbike-linked fatalities and more than a third of the injuries in Canada (Canadian Paediatric Society [CPS], 2004).

North American geography and social settings vary enormously, and it is indicative of the predominance of epidemiological studies on quadbike LCE that studies from these countries do not reflect this diversity more. These quite different contexts of use are rarely incorporated in the analysis - and occasionally not even in the title. For example, the study ***All terrain vehicle ownership, use and self reported safety behaviors in rural children*** (Warda, Klassen, Buchan & Zierler, 1998), carried out in the flat but climatically-extreme Canadian prairie Province of Manitoba.

A notable exception that does provide very useful data on context of use is the report from North West of Alaska on the ***Norton Sound youth ATV project: a broad-based strategy promoting ATV safety. In*** northern areas of Canada and Alaska with high snowfall and fewer roads, the uptake of quadbikes is reportedly very high indeed and there is more utilitarian usage than is the case in more southerly parts of North America (Ferguson & Hill, 2005). In a very interesting and the only community-based study the literature search revealed, Ferguson found that in one village of 700 predominantly indigenous (Canada's First Nation) people there were 300-400 quadbikes. All ages, and both male and female used them in the place of more expensive 4WD cars and trucks or horses for getting to school, work, shops etc. during those months when conditions permit. In deep snow only snowmobiles can cope.

Snowmobiles are widely used in place of, or in conjunction with, quadbikes in both Canada and northern Scandinavia. In 2000, Quebec, with a population of 7.4 million had 223,000 quadbikes and also 149,000 snowmobiles (Legare, 2002). This can confound attempts to identify quadbike-only data in studies on ATV incidents as

both are commonly included. Snowmobiles are used occupationally as well for example in reindeer herding by Lapps (Pekkarinen, Anttonen & Hassi, 1992).

Recreational riders in all countries reporting quadbike injuries appear to be younger than the New Zealand riding population. The mean age of 462 hospital-treated ATV riders in Kuwait was just 17.8 years (Ahmed, Khan, Al-Asfar & Al-Awadi, 2005).

Quadbike usage in Ireland (Moroney, Doyle & Mealy, 2003) and Britain (Jagger, Vernberg & Jane, 1986; Jagger & Widome, 1988; Crichton, 2006) is reported to align more closely with that of New Zealand than with North America, but uptake of the machines is apparently far lower. The Health and Safety Laboratories (HSL) in the UK reportedly conducted a study of approximately 50 in-depth field investigations in the late 1990s but this work has not been published and has proved untraceable although one case study that may be from this set is available electronically (Health and Safety Executive [HSE], 2001). The 350 word summary of events, outcomes, findings and lessons learned appears to reflect a sensibly broad investigative approach and it is a pity that this work was not taken further, or reported more fully, whichever may be the case. The HSL specialist engineer responsible for quadbike issues had no recollection of the work when interviewed by the researcher at the laboratories in Buxton, UK in 2006.

Research of any sort after the initial surge of research interest in the 1980s has been minimal, and from countries outside North America especially. The studies that have been published generally give little indication on the context of use or factor interactions in common LCE scenarios as they are epiderniologically-based and attempt to formulate intervention strategies based on the very limited data held in formal records – generally fatality investigations. Australia is an example of this (Fragar & Pollock, 2003) approach.

Researchers in Scandinavia (Erikson, 1996; Kartunnen, 2003) and Canada (Simpson et al., 2004) have produced some interesting papers on underlying factors such as stress contributing to farming injuries and ill-health, but again, these findings are not

directly linked to quadbike LCE scenarios (Pekkarinen, Anttonen & Mielonen, 1997). This is surprising given the established association (Lagarde, Chastang, Gueguen, Coeuret-Pellicer, Chiron, & Lafont, 2004) between increased road traffic accidents and stressful life events such as marital breakdown, hospitalization of family members, children leaving home and major financial changes. These apply as much to farming families as any other, and so the absence of similar studies of off-road vehicle use represents a gap in the body of knowledge.

2.4 Interventions

.... there has been a lot more written on how to describe patterns of failure than there has been on how to reliably develop well-matched interventions. (Wiegmann & Shappell, 2003)

Very little has been formally tried in New Zealand to reduce the incidence or severity of injuries linked to quadbike LCE, and no evaluation of any of these measures has been attempted other than some secondary engineering tests relating to standards for the much-disputed concept of fitting Roll-Over Protective Structures (ROPS). The difficulty of enforcing interventions in the farming sector generally has been noted and the practical advantages highlighted of introducing inherently safer products instead. In the USA the major initiative was the Consent Decrees which placed certain restrictions obligations on manufacturers from 1987 for ten years. The Consumer Product Safety Commission (CPSC) who designed the Decree claim substantial success in steering the industry, but other sources are less convinced that the measures were as effective as claimed, and even whether they were the right ones (Ford & Mazis, 1996). Given the intensely litigious environment though, considerable care is needed in screening the North American literature to establish potential sources of commercial bias. Most of the interventions evaluated in North America address risk factors dominant amongst children in their recreational rider population, and increasingly they are protective measures such as the use of helmets.

Farm safety initiatives generally appear to have been poorly evaluated in the past. De Roo & Rautianinen et al (2000), in their systematic review of farm safety intervention papers, reported that injury incidence comparisons pre and post-implementation were made in only three of the 25 cases (23 from the USA, two from Scandinavia) that were analysed. Recommended improvements in study design for farm safety intervention evaluations included the use of control groups, randomisation of study subjects and the objective measurement of outcomes.

2.4.1 Interventions in New Zealand

New Zealand interventions comprise mainly training (ACC, 2001) and safety awareness measures (ACC, 2001a; ACC, 2001b). As can be seen in Table 2.8, there has been very little evaluation of the interventions tried in New Zealand.

Table 2.8 Interventions implemented for machines used in New Zealand farming

Date introduced	Intervention	Evaluated
1980s	Roll over protective structures (ROPS). OSH, 1998a Unreleased Guidelines. Plenty in use around the country of various designs, many DIY. Commercial manufacturing ceased around 2000. Reduced demand has been accredited in part to the Honda campaign which used data from their simulation studies to conclude that ROPS increased risk. Other factors include engineering changes to quadbike frames, making them of lighter gauge steel tubing at the back and hence harder to safely attach ROPS to.	Engineering integrity only (Barbour, 1998). The mountings were found to be the most likely weak points Low (2000) proposal for evaluation - not funded
	Warning stickers on limitations of machines - placed by manufacturers	No
Early 1990s Late 1990s 2004	Training: • Private training providers and Agricultural colleges • New Zealand Qualification Authority Unit Standards x 3 • FarmSafe Skills - ATV	No
1990	Publications. OSH and ACC newsletters, leaflets and videos	No
2002	Industry Guidelines. Safe Use of ATVs on New Zealand Farms: Agricultural Guidelines	No

Interventions proposed but not implemented include: regulated maintenance of quadbikes similar to Warrant of Fitness (WOF) checks on cars, new concept vehicles that provide protected occupant zones and customised load carriage systems, prosecution of those who allow under-age use, electronic auditory roll-over warning device, and in-house skills competency testing methods. In most cases, those advocating specific interventions supported by data in this country are citing findings

from US research, for example, Wren (2002) with regard to helmets, and Kahler on a number of issues (ACC, 2000).

Amongst these is the contention by Kahler – an Australian engineer, that the ability of the rider to weight-shift in order to ride safely is not essential as the manufacturers and trainers claim (Kahler, 2000). Better Active Riding through training and rider information programmes has been offered as an intervention. He cites calculations by fellow engineer Karnes, Leonard and Johnson (1989) which indicate that 'active riding' can move the centre of gravity only four inches - which is not enough to significantly influence rollover LCE. This conclusion is interesting, but has been dismissed loudly by both users and suppliers of quadbikes, with practical demonstration days offered to prove that in a dynamic setting far more control is possible than may be suggested by modelling.

The importance of this debate, is that the manufacturer's argument against ROPS is strongly supported by an acceptance of the need for active riding. The rider can't weight shift while wearing a seat belt restraint, and ROPS have been found to only prove fully effective when used in combination with a restraint that keeps the rider within the protected zone.

It has been suggested in New Zealand and a number of other countries, that the use of ATVs has been under-regulated since they first appeared. (Langley et al., 1995; Delisle et al., 1989; Moroney et al., 2003). In New Zealand there is no legal requirement to register or gain a warrant of fitness for quadbikes used solely on private land. An effective intervention for keeping the worst of poor condition cars off the road was the move to make it illegal to sell a road vehicle without a WOF, but this does not apply to quadbikes. People of 12 and over can drive a tractor in New Zealand if they are family members – which is young by international standards (Langley, 1996). Tractors are defined as weighing at least 0.7 tonne and as all quadbikes weigh less than the 700kg limit even family members under 12 years of age can legally ride them (Land Transport Safety Authority New Zealand [LTSA],

2000). There is no regulatory control on the carrying of passengers of any (species or) age in New Zealand.

Marshal1 et el (1996), suggest that given the nature of farming in New Zealand, passive measures that provide inherently safer designs of quadbike are likely to be more successful than interventions that require policing such as restriction of use through regulation.

2.4.1.1 Intervention approaches

The New Zealand literature, however, broadly supported the adoption of system-wide programme approaches to problem analysis, intervention design and implementation. Drawing upon experience in this country, and in particular the critical success factors in road traffic safety, Slappendel includes the following points in the Nov 2002 draft New Zealand Injury Prevention Strategy (NZIPS, 2002)

> "Current evidence suggests that injury prevention will work best when it:
>
> - Addresses the multiple factors that contribute to injury
> - Encourages environmental and behavioural changes
> - Engages the people who are most at risk
> - Involves action across sectors (e.g. Police, health, education)
> - Is sustained and reinforced over time."

These findings are broadly consistent with the recent published findings of overseas researchers in the social sciences (Nation, 2003; Wandersman & Florin, 2003). Nation lists nine principles associated with successful prevention programmes in the area of negative behaviours of at–risk youth, which encompass varied delivery and sensitivity to individual and interpersonal needs while also operating comprehensively at a community level. The multi-component approach seeking to modify the overall context within which the problems can emerge – not simply to manipulate the individual 'risk or protective' factors as Wandersman and Florin refer to them.

Incorporating community-level intervention methodologies is relevant with regard to quad bikes as the findings reported in Chapter 4 indicate the extent to which injuries connected with their use are a community-wide issue in our rural areas. They are not just used by a discrete occupational group of farmers.

As pointed out also by Marshal1 et al. (1996), practices in the agricultural industry are costly to control by regulation. Department of Labour inspectors have many scattered farms to visit, and much of the work takes place away from the main farm buildings and out of the sight of any but the most determined of visitors. Historically, the farming lobby has also had considerable success in holding on to the right to control what they do on private land. NZ Governments have shied away from banning or making mandatory anything that cannot be policed fully on farms, not least to avoid the political embarrassment that would come from widespread flouting of an unpopular new legal requirement. For example, bicycle helmets were made mandatory; helmets for quadbikes used on private land however are just strongly recommended. In comparison to more easily policed sectors such as manufacturing, a greater proportion of interventions in this industry are adopted voluntarily rather than enforced.

While community-based approaches have general support though, a barrier to their gaining adequate commitment from funders may be the problem of proving effectiveness. During the context study the comment was made by a senior government employee involved in injury prevention that educational messages and awareness campaigns were easier to secure support for in New Zealand because the evaluation methods such as mass phone surveys for single variable interventions asking 'can you complete this phrase used in the recent television ads ……' could be achieved far more easily and cheaply. Her conclusion was that until suitable evaluation methods existed, system-wide injury prevention intervention packages in at-risk communities would continue to struggle for support. Wiegmann and Shappell (2003) note that the evaluation of system-wide intervention programmes can also be fundamentally difficult to design. "Problems in the securing of meaningful control

communities, and with randomisation - are the norm''. Further work is clearly needed to address this methodological deficit.

2.4.2 Interventions for farm quadbike LCE overseas

There are very few North American studies that identify interventions specifically designed for or evaluated specifically in occupational farm settings. A large proportion of the more recent publications on interventions are concerned solely with addressing risks to children using quadbikes for recreation (Aitken, Graham, Killingsworth, Mullins, Parnell & Dick, 2004; Keenan & Bratton, 2004). Hence the bulk of the literature reveals little of direct relevance to the question of what may reduce the incidence or severity of quadbike LCE on New Zealand farms.

A major in-depth investigation of 287 incidents was carried out in 1985 by the US Consumer Product Safety Commission (CPSC), and was used subsequently in analysis of potential interventions by Ayres, Gross and Fowler (1991). However, the target group appear too dissimilar to the riders found on contemporary New Zealand farms for any useful comparisons to be drawn. The interventions were all aimed at recreational riders. An indicator of this is the fact that Ayres was seriously evaluating the potential effectiveness of quadbike mounted flags as preventative devices. Recreational riders congregate in groups at undulating sites with good jumps, gulleys etc and so colliding with each other as they race repeatedly over blind ridges is a recognised risk that a flag on a long aerial may reduce. Brown's work in Southland suggested that in New Zealand usage was by individuals who generally work in isolation and at low speeds.

The use of ROPS has been resisted by the manufacturers. One possible reason for this which has been voiced anecdotally during this research, is that their acceptance of ROPS as a viable intervention could be seen as a tacit acknowledgement of a fundamental design weakness with quadbikes, and open the door to legal action forr the thousands of families affected by ATV-related deaths and serious injuries in the last 30 years. US$2 million has been spent by manufacturers in defending their

assertion that ROPS are dangerous - according to Honda New Zealand (Cooper-Smith, 2004).

Evaluations have been conducted using un-helmeted instrumented dummies (Piziali 1992) in the USA and computer simulations in both Britain (HSE, 1999) and the USA (Zellner & Van Auken, 1998). All of these concluded that ROPS have the potential to limit necessary rider mobility and also to act as mechanisms of more serious injury in the event of a rollover where the rider is thrown out of the seat but not clear of the vehicle and its path entirely. The steel tubing, it is argued, provides a greater point load on the body than more rounded blunt vehicle parts that would contact otherwise.

The HSE report concedes that in slow speed rolls where the rider stays in position there may be merits as the ROPS will arrest roll at 90 degrees protecting the vehicle and occupant from damage. The Zellner study, paid for by Honda, concedes less. Some other vehicles such as agricultural tractors that are prone to tipping due to design, function or context of use (Flynn & Stoffregen, 1995) have been studied relatively thoroughly in comparison to quadbikes. There has also been experimentation with a variety of devices for providing, usually auditory, tipping warnings.

It has been suggested since the early days of quadbike use that the slope safety warning units found to be of benefit with logging vehicles and ride-on mowers for example could be fitted to quadbikes (Lerner, 1985). Others have commented however that the quadbike moves too fast, is too high above the ground, and is on micro-terrain too variable for such a device to be of use (Ayres, Bjelajac & Fowler, 1997). No evaluations were found in the literature that related specifically to quadbikes, although there has been work of relevance (Leonard & Karnes, 1996) on the ability of operators to discriminate safe from unsafe slope angles. Leonard & Karnes found that rider ability to detect safe angles of work was significantly affected by factors including the presence of reliable reference points, the sequence

of presentation (is the slope getting steeper or flatter at each pass), and accurate judgement of the stability of the equipment involved.

The Consent decrees on ATV are claimed by Rodgers (1993) to have reduced: sales of these 'inherently risky products' by 46%, emergency room treated injuries by 30,000 (7%) and ATV-related fatalities by 9%. He attributes these reported gains to: consumers being better informed about the explicit risks, more stringent age controls, free training to all new buyers, the absence of three-wheelers in the market and the addressing of some specific safety concerns through the adoption of a voluntary standard on design. In the absence of a control group of ATV users who experienced all the other changes of this period – but not the decrees, clear attribution of credit cannot surely be made confidently though.

Personal protective equipment (PPE) has been a major focus of interventions in North America (Ayres, Fowler, McCarthy and Merala, 1994). Use has been even more actively encouraged, but adopted to widely varying degrees, throughout North America since the US decrees of 1998. In Canada however levels of helmet use as low as 3% are still reported in some places (Su, Hui & Shaw, 2006). No study suggests their effectiveness on farms but Rodgers (1998) uses regression analysis to conclude that helmet use decreases the likelihood of death by 42% and injury by 64%. However, the case data are taken from a CPSC 1985 study which may well have involved mostly three-wheelers, and the activity will be mostly, if not totally. recreational.

Interventions suggested in the peer-reviewed literature in the USA but not implemented include full body armour for riders (Rios-Reboyras, Grovis, Ramirez, Zierenberg, Otero & Vilella, 2002), which again indicates predominant recreational use of the machines in that country.

2.4.2.1 Intervention approaches

The lessons to be learned from overseas are more limited than intervention designers in New Zealand have assumed to date. The dominant category of research now being published in North America are epidemiological studies on factors influencing injuries to children who are assumed to be using quadbikes in a recreational setting (Keenan & Bratton, 2004; Aitken et al., 2004; Killingsworth, Tilford, Parker, Graham, Dick, & Aitken, 2005; Graham, 2006; Gittleman, Pomerantz, Groner & Smith, 2006). Of more relevance to New Zealand are methods used in the comparative studies between regions on the effectiveness of regulation of quadbikes in workplaces, for the population as whole (Su et al., 2006) or for young people in occupational roles (Gadomski, Ackerman, Burdick & Jenkins, 2006).

Of more direct interest, however, is the recent work by Ferguson and Hill (2005) in the remote communities of North West Alaska where a series of key informant interviews, focus groups and discussion groups, all within the district, resulted in the development of a 'broad-based toolbox of interventions'. This toolbox included recommendations for the provision of a helmet that would be stylish enough to actually appeal to the potential users.

The specific findings from Ferguson's work are less relevant to New Zealand than the methodology. By moving beyond a reliance on epidemiological data and remotely conducted telephone surveys the researchers were able to build an understanding of the context of quadbike use and thereby identify both present and potential barriers to the uptake of interventions.

Methods of influencing change in scattered and independently-spirited small rural businesses have been studied specifically in the USA during the last century. Diffusion Theorists have studied the adoption or rejection of innovations in agriculture throughout the 20th century (Tarde, 1903; Rogers, 2005). An important early study in farming was the 1943 paper The Diffusion of Hybrid Seed Corn in Two Iowa Communities in the journal Rural Sociology by Ryan and Gross (1945). They concluded that "the adoption of innovation depends on some combination of

well-established interpersonal ties and habitual exposure to mass-communication". Their paper appears to have been highly influential, and is heavily cited in the subsequent Diffusion Theory literature.

Rogers in the 1995 4th edition of his book *Diffusion of Innovations*, credits Ryan and Gross with having identified the five key stages in the adoption process (awareness, interest, evaluation, trial and adoption), but notes that it was not until the 1990s when researchers conducted more formal measurement of the interpersonal links that it began to emerge just how influential in adoption the networks between farmers can be. He suggests that in the light of these more recent studies " the diffusion of an innovation is essentially a social process that occurs through interpersonal networks."

The literature on Diffusion Theory and State of Change has relevance for this research on quadbike LCE on NZ farms in two ways. Firstly it emphasises the importance of understanding context prior to investigating individual incidents; the overall fatalism of the farmer for example is highly relevant, as this will influence the type and range of LCE risk factors identified. Secondly, iteratively testing the potential intervention list at each visit appears valuable in principle, as the responses from the riders serve not only to refine the intervention design, but also to indicate the state of readiness of the industry for such a change, plus insights into potential vehicles of implementation.

2.5 Discussion

2.5.1 Scale

In recent years the costs of new claims for injuries has risen markedly, and the costs of ongoing claims even more so. The data used however came solely from ACC and OSH sources, where accuracy is reliant on comprehensive and reliable data gathering, capture and analysis, which cannot be assumed. Also the indirect costs to the riders affected – most of whom are self employed - remain uncalculated. Estimates of the full social costs of quadbike LCE are an important area for further study.

The analysis conducted during these studies allowed more confident comparisons to be made as the ACC data were individually screened case by case, to positively identify farm quadbike LCE. The analysis revealed that the population of quadbike riders on farms en masse have a higher risk of injury than the New Zealand car driver population, but less chance of death. One in 29 riders on farms will file a quadbike-related injury claim to ACC in a 12 month period, as opposed to one in every 43 car drivers who will be hurt in a road traffic incident. However, one in 10,000 riders on farms will die from quad-related incidents per year, as opposed to one in 4,000 car drivers who are killed on the road. This underlines the lack of intrinsic injury protection for quadbike riders, and the impact of vehicle speed on injury severity. Cars are going faster - there is 'more initial energy marshalled' as Haddon would express it (Table *5.2).*

2.5.2 The context and nature of LCE in New Zealand

The most significant gaps in knowledge are concerned with firstly the context of quadbike use on New Zealand farms, and secondly the detailed nature of the LCE taking place there.

It is evident from the literature that per capita usage of quadbikes is very high in New Zealand farming by international standards, and that the cost savings brought by quadbike use on farms have contributed to fundamental changes in the dynamics of rural communities. Apart from manufacturers' sales figures, this is also evidenced

indirectly through the steadily increasing proportion of media coverage of quadbike-related stories.

How exactly the machines are used, for what, by whom and with what modifications, remains undocumented. Incident-dependent contextual detail has not been collected in the richness that is needed to understand the underlying risk factor interactions behind quadbike incidents, nor to formulate broad-based LCE minimisation strategies. The two studies carried out to date in New Zealand that might have provided much needed data of these kinds have had important weaknesses. These were methodological and administrative shortcomings in the case of the now-dated OSH work in Southland and by systematic bias towards presenting the views of the farm-owning population in the case of the Federated Farmers / OSH study in the late 1990s.

The recent work (Basham et al., 2006) by sociologists at Waikato University makes a valuable contribution to the debate on underlying community issues, such as childcare availability, behind quadbike LCE involving children as passengers. Other social factors warrant similar macro-level research attention including the impact on health and safety of: personal debt levels, staffing reductions, rural population depletion and the increasing employment of staff from town with no experience of handling big animals.

ACC and OSH, the government bodies effectively responsible for injury prevention, are in a weak position to develop evidenced-based intervention strategies as their epidemiological studies are limited by the quality of the databases available. The completeness and reliability of their data have also been criticised recently by the National Occupational Health and Safety Advisory Council. NOHSAC Committee Project Manager Mark Wagstaffe (2005) suggests that 'up to 80% of work-related deaths are neither documented nor investigated' leaving 'huge gaps in what is collected'. As reporting is mandatory for fatality and serious harm cases, the degree of under-reporting or inaccurate reporting of lesser injuries can be safely assumed to be no better.

The OSH investigation reports from the regional offices are potentially a valuable source of data on quadbike LCE risk factors, but there are presently serious inadequacies in investigation design, variance of administration and an absence of centralised analysis. The 18 detailed investigation reports brought together by Weng Low of Auckland OSH did however raise some interesting points after analysis. In particular, that 17 of these were rollovers, and that almost all took place in dry weather on predominantly hard surfaces that may have been wet or slick on top.

The media collect material directly from the people involved, but analysis of interventions mentioned in the articles in the 2001-06 newspaper search shows an absence of coverage of the larger issues such as workload pressures, task planning, machine maintenance, emergency communications, supervision, training and machine selection. This improved after the release of the ATV Guidelines by the Agricultural Health and Safety Council in 2002, but the key messages have not been systematically reinforced by the media on such occasions as it had been hoped.

The media coverage analysis also shows an over-representation of the more sensational cases such as fatalities amongst very young people, in comparison to the far more common problem of unspectacular but long term debilitating quadbike injuries amongst older riders.

2.5.3 The context and nature of LCE overseas

Little data exists on usage patterns overseas, and country-wide surveys in places as geographically and socially diverse as the USA may be of limited usefulness. It appears clear, however, that there are areas of higher occupational quadbike use such as Britain, Ireland, Australia and possibly Alaska, where some studies are being sporadically done, and which may have relevance for New Zealand. In the countries conducting most of the research though – the USA and Canada, the predominant use is clearly recreational and their operating circumstances differ accordingly. These riders often ride in groups, at speed, and may stay in one particular area with good jumps, stream crossings etc for a period, creating risks of collision with other

machines as well as natural objects. They do not operate as New Zealand farmers do, frequently away from tracks, in isolation, with daily use, at low average speeds and with big loads and trailed implements. This recreational user group is also younger and less experienced than the occupational users in their own country.

Ranch and farm usage is reportedly growing in the USA markets according to CPSC, and if so, then there may be more market-driven consideration of farming needs in future quadbike designs in the USA that could be beneficial in New Zealand too. There may also be more common areas of interest for quadbike LCE researchers.

2.5.4 Interventions

None of the very few interventions implemented in New Zealand (skills training, hazard awareness leaflets, ROPS, industry guidelines) have been formally evaluated as to their effectiveness in reducing the incidence or severity of injuries.

Attempts to effect behavioural change through the use of tertiary protective measures (Laughery & Hammond, 1999) - such as warning stickers that neither alter the design nor provide guarding against the hazard - appear from the anecdotal data in the media to be ineffective in the New Zealand context. An example of this disregard is the recent Vanner case. The Suzuki quadbike which the eight year old Molly Vanner was riding under the guidance of her father when she died had 12 warning stickers on it, all still legible on the new machine, one of which stated that it was only designed for the operation of those over 16 years of age. Her father was acquitted of manslaughter charges after an outcry from the rural community stating that this was normal practice, which clearly was largely accepted by the court. The conclusion by Marshal1 et al (1996) that inherent changes to the design of the machinery are preferable to attempts at behavioural change, are supported by findings such as this. Agriculture is a scattered industry based on private land where unpopular regulations are very costly, if possible at all, to enforce.

However, any changes to design need to include retrofitting of existing machines. The interventions being applied now to the latest model machines in the dealerships will have a long latency period – as has been noted in Australia in the recent work to get ROPS on all tractors (Franklin, Starka & Fragar, 2006). From their survey the authors from the Australian Centre for Agricultural Health and Safety also concluded that any retro-fitment campaign needs to ensure that the appreciation of the need for the safety item is created and that barriers to adoption are addressed.

2.6 Conclusions

The aims of this review were to critically analyse the existing body of literature relating specifically to quadbike LCE, quadbike use and interventions; and to discuss established knowledge, gaps in understanding and conflicting evidence. It was found that little reliable and relevant research data have been published. The most significant gap in knowledge regards the context of quadbike use on New Zealand farms, and the detailed nature of the LCE taking place there. There is sufficient evidence on the use of quadbikes in North America however, to conclude that interventions designed for this population are not transferable to a New Zealand farming context, but this may change with time.

Conflicting evidence in the literature relating to the New Zealand situation is minor, but where it does occur, it appears to stem from attempting to merge North American findings and intervention ideas with New Zealand data. Greater homogeneity has been assumed than is actually the case. For example US data on head injuries has been used as justification for helmet promotion taking high priority in injury prevention initiatives without it being referenced as such. Conflict occurs when local data are then added to the debate.

The review revealed that the cost burden of occupational quadbike LCE on New Zealand farms is substantial, and that it continues to grow. In particular, the average cost of the more serious injuries – ones where ACC continue to pay medical and or compensation for longer than a year, is greatly outstripping the rate of uptake of the machines. This implies an increase in the severity and/or rehabilitation times for these cases in New Zealand. Interestingly, recent work in the USA shows no trend of increased severity for those injured using quadbikes in that country – further supporting the assertion that the differences in quadbike use between the two populations are significant.

There is very little published literature on the context of use or the specific nature of occupational farm quadbike LCE either here in New Zealand or overseas that is

rigorous, comprehensive or current enough to guide intervention design for New Zealand farms.

The epidemiological studies have been hampered in this country and others by the difficulty of accurately identifying quadbike incidents specifically in centralised data; use of the umbrella terms ATV or Farmbike in narrative confuse the picture. As a result this area of research in New Zealand has been under-measured at a national level, and poorly understood in contextual detail.

Few studies have provided any usable data on risk factors for farm quadbike LCE in New Zealand. None have produced any findings on risk factor interactions from which interventions might be developed that address all relevant aspects of the systems.

Detailed, holistic investigations of these off-road LCE have been recommended by a number of authors. In comparison to road-traffic incidents, off-road injury events have received very limited research resources. Some priorities for further research have been identified based on this review.

A more detailed understanding of the contemporary New Zealand rider population and their activities is needed in the various regions. Research exploring the relationships between occupational quadbike LCE and underlying risk factors such as stress, debt and family support in rural communities appears to be warranted too.